Percutaneous Ablation for Small Renal Masses—Complications

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Abstract

Although percutaneous ablation of small renal masses is generally safe, interventional radiologists should be aware of the various complications that may arise from the procedure. Renal hemorrhage is the most common significant complication. Additional less common but serious complications include injury to or stenosis of the ureter or ureteropelvic junction, infection/abscess, sensory or motor nerve injury, pneumothorax, needle tract seeding, and skin burn. Most complications may be treated conservatively or with minimal therapy. Several techniques are available to minimize the risk of these complications, and patients should be appropriately monitored for early detection of complications. In the event of a serious complication, prompt treatment should be provided. This article reviews the most common and most important complications associated with percutaneous ablation of small renal masses.

Keywords
- radiofrequency ablation
- cryoablation
- kidney cancer
- complication
- interventional radiology

Objectives: Upon completion of this article, the reader will be able to identify complications following of percutaneous ablation of renal tumors and the treatment methods used to address such complications.

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Percutaneous treatment of small renal masses is evolving, with treatment generally reserved for poor surgical candidates; surgical resection remains the first-line therapy for limited renal cell carcinoma (RCC). Patients who are ineligible for or decline surgery may be treated with percutaneous ablation or observed. Despite the presumably more invalid patient population selected for renal ablation compared with surgery, major complications are infrequent and generally manageable.

This review summarizes the data regarding complications from trials of the ablation technologies most commonly used to treat renal masses, specifically radiofrequency ablation (RFA) and cryoablation. Examples of the most common complications to occur during renal mass ablation are provided. Techniques to minimize risk of these complications and manage their outcome are also discussed.

Classification of Complications

The revised Clavien–Dindo classification system is now commonly applied to complications from renal mass ablation.[1–3] This surgical classification system grades complications I to V based on deviation from the expected postoperative course and the level of intervention required for management of the complication. Specifically, a grade I complication does not require intervention; a grade II complication requires pharmacologic intervention; a grade III complication requires surgical, radiologic, or endoscopic intervention; a grade IV complication is a life-threatening complication requiring intensive care unit management; and a grade V complication is death.

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Various authors have classified complications using other systems, including the Society of Interventional Radiology classification system and the Common Terminology for Classification of Adverse Events established by the National Cancer Institute.[4,5] However, as the urologic community has increasingly embraced the revised Clavien–Dindo system in its literature and as clinical guidelines compare nephron-sparing interventions for small renal masses based on complication rates, acceptance of and facility with the revised Clavien–Dindo system seems prudent.[3,6]

Overall Frequency of Complications

Complications following renal ablation are seen infrequently. A multi-institutional review of 271 RFA and cryoablation procedures demonstrated an overall complication rate of 11%.[7] However, inclusion of both intraoperative and percutaneous treatments in this review confounds interpretation of the outcomes. A meta-analysis comparing percutaneous and surgical renal ablation procedures found a significantly lower major complication rate of 3.1% for percutaneous ablation versus 7.4% for surgical cases.[8] Review of several large series of percutaneous renal RFA from the literature reveals an overall complication rate of 8 to 13% with major complication rates of 4 to 6%.[9–11] Review of the literature also demonstrates a 5 to 7% major complication rate following percutaneous renal cryoablation.[12–14]

Risk Factors for Major Complications

A recent review of complications following 573 renal ablation procedures at the author's institution included 254 RFAs, 311 cryoablation procedures, and 8 combined procedures.[1] The overall complication rate was 11.3% (65/573), and the major complication rate was 6.6% (38/573) procedures. Major complications occurred more commonly following cryoablation (7.7%; 24/311) than RFA (4.7%; 12/254) ($p = 0.15$). Risk factors for major complications included: advanced patient age, increased tumor size, increased number of applicators (cryoprobes), and central location of the target renal mass; advanced patient age was also a risk factor for a major complication. The overall increased risk of complications with cryoablation in this series is likely the result of selection bias, as larger tumors and tumors extending centrally in the kidney were more likely to be treated with cryoablation. A review of percutaneous ablation procedures on renal masses measuring 3.0 cm or smaller showed no difference in major complication rates between RFA (4.3%, 10/232) and cryoablation (4.5%, 8/176).[15] In interesting contrast to surgical outcomes, one study has shown a similar incidence of complications in morbidly obese patients compared with normal weight patients.[16]

Complication Types

Complications following renal tumor ablation may occur as a result of injury to the kidney, including its vasculature and the upper urinary tract collecting system, or injury to the surrounding structures. Urologic complications include hemorrhage, ureteral stricture, urine leak, and urinary tract infection. Nonurologic complications include pneumothorax, nerve injury, skin burn, tract seeding, and other less common medical events.

Hemorrhage and Renal Vascular Injury

At least some element of hemorrhage is an expected outcome following percutaneous puncture and ablation of a renal mass. Most scans during or immediately following renal ablation procedures will show evidence of perinephric hemorrhage, regardless of the ablation technology used. If intravenous contrast is administered immediately after cryoablation, bleeding may be seen along the applicator tracts (►**Fig. 1**). Significant hemorrhage may manifest as a large retroperitoneal hematoma on imaging, hemodynamic disturbance during or following ablation, or symptomatic anemia or hematuria. Alternatively, postablation imaging may reveal evidence of significant vascular injury, such as intraparenchymal pseudoaneurysm or arteriovenous fistula (►**Fig. 2**). Asymptomatic hematuria may occur postablation,

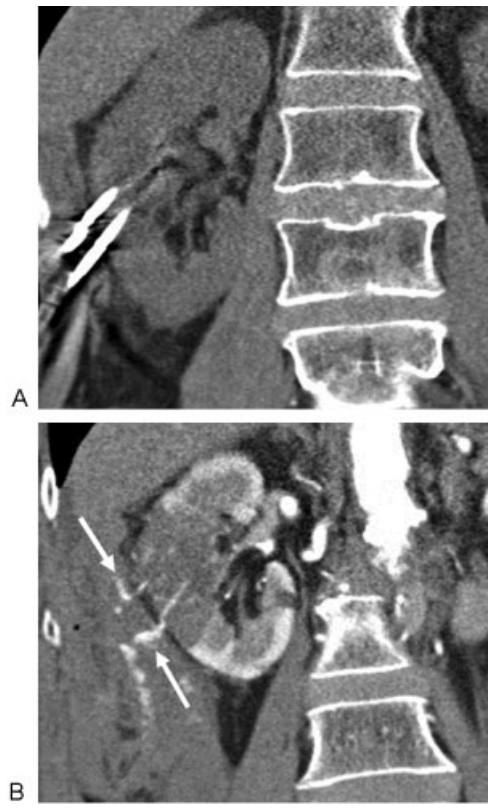

Figure 1 Active extravasation along cryoprobe tracts. (A) Coronal reformatted unenhanced CT during cryoablation shows two of three cryoprobes placed in a 3.7-cm central mass in the right mid kidney of a 72-year-old man. (B) Coronal reformatted contrast-enhanced CT shows active contrast extravasation along the probe tracts (arrows). The patient remained hemodynamically stable, despite a 3.1-g/dL drop in hemoglobin. No expansion of the initially large hematoma was demonstrated on two serial CT scans at 20 and 90 minutes postablation. No transfusion or embolization was performed. CT, computed tomography.

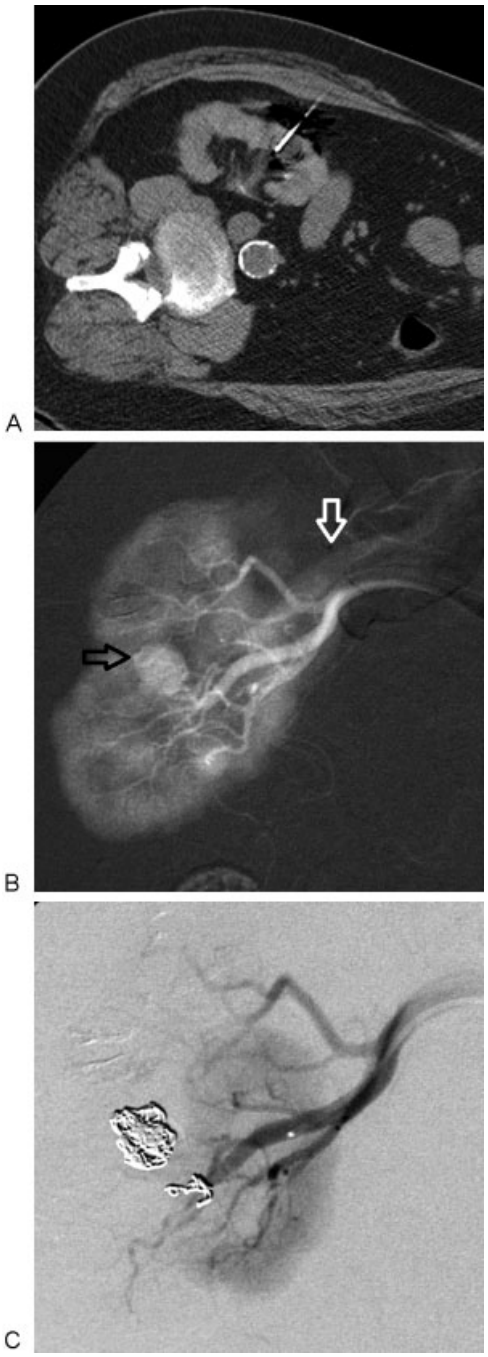

Figure 2 Renal arterial pseudoaneurysm and arteriovenous fistula following radiofrequency ablation. (A) CT shows an electrode in a right renal mass in a 70-year-old woman. (B) DSA image of the right kidney shows a pseudoaneurysm in the right renal hilum (black arrow) as well as early filling of the right renal vein (white arrow). (C) DSA image showing control of the vascular injury postembolization. CT, computed tomography; DSA, digital subtraction angiographic.

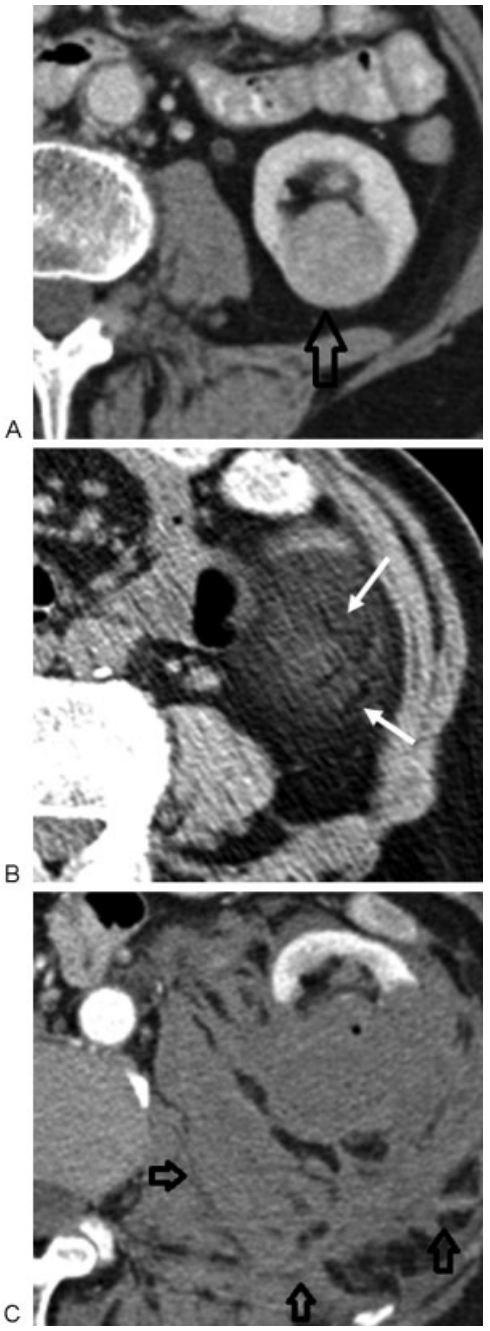

Figure 3 Hemorrhage from ice ball fracture. (A) Contrast-enhanced CT before cryoablation shows a central 4 cm left renal mass (arrow) in an 84-year-old woman. (B) During cryoablation, a fracture (arrows) developed within the ice ball, observed early in the second freeze cycle. (C) As expected, following the cryoablation, a large retroperitoneal hemorrhage developed (arrows). The patient remained hemodynamically stable, despite a hemoglobin drop of 2 g/dL, and did not require treatment. CT, computed tomography.

but hematuria resulting in ureteral obstruction can be of particular importance in patients with solitary kidneys.

Hemorrhage is more commonly seen following renal cryoablation than RFA, occurring in one series in 4.8% of cryoablation procedures compared with 1.2% of RFA procedures in other series.[1] Thermal coagulation induced by radiofrequency electrodes likely decreases hemorrhage following RFA, and cryoprobes have generally been of larger caliber than most RFA electrodes. Platelet function is also compromised at low temperature.[17] Additional risk factors for hemorrhage following renal cryoablation include large tumors, central tumors, and an increasing number of applicators. Ice ball fracture during cryoablation may portend a bleeding complication (►**Fig. 3**).[18]

Minor, asymptomatic hemorrhage following renal ablation may be seen. Serial CT scans immediately following ablation and frequent assessment of patient hemodynamics may determine the necessity of intervention. The threshold for intervention may differ between patients based on underlying comorbid disease, such as anemia and coronary artery disease. Hemodynamic disturbance may prompt angiography with embolization as well as volume support or blood transfusion. Significant hematuria may require bladder catheterization and irrigation. Anuria following ablation in a solitary kidney is often due to ureteral obstruction, warranting ureteral stent placement.

Urothelial Injury

Thermal injury to the urothelium has been reported more frequently following RFA than with cryoablation. Early series of renal mass RFA report several cases of stenosis of the proximal ureter or ureteropelvic junction related to the unrecognized risk of thermal injury to the urothelium.[1,8,9,11] In some cases, such an injury may lead to severe renal dysfunction or loss of the renal unit.[7] The proximal ureter is most prone to injury during ablation of medial, lower pole renal masses (►**Fig. 4**). Direct puncture or thermal injury of the collecting system can lead to urine leak in addition to stricture. Animal studies have suggested that cold-induced urothelial injury during cryoablation is less common than injuries from heat-producing modalities.[19,20]

Retrograde pyeloperfusion, using slow infusion of 5% dextrose in water through a ureteral stent, has been advocated to minimize the risk of ureteral injury.[21] A ureteral stent placed before ablation also improves visualization of the ureter and may allow better monitoring of its proximity to the ablation zone. Gentle cryoprobe retraction after the first few minutes of freezing can displace the kidney within the retroperitoneal fat and increase the distance between the ice ball and the ureter.[22] In patients felt to be at high risk for ureteral stricture, particularly those in which the ablation zone clearly abuts or includes the proximal ureter, a temporary indwelling ureteral stent may be left in place for several weeks as the urothelium heals.

Urinary leaks may be seen immediately postablation and are usually self-limited (►**Fig. 5**). Rarely, percutaneous drainage of a persistent urinoma and/or temporary placement of a ureteral stent for diversion may be required.[9]

Infection and Bowel Injury

Infection is a potential complication of any percutaneous ablation procedure. Infection involving the ablation zone or urinary tract occurs in fewer than 1% of cases.[1,8,23] Particularly serious are infections related to bowel injury. Ablation into the bowel wall can cause perforation and lead to development of a colonephric fistula (►**Fig. 6**). These infections may require percutaneous drainage or surgical repair.

Several maneuvers may be performed to avoid injury to bowel adjacent to the target renal mass. Patient repositioning can lead to a greater distance between bowel and the renal mass.[23,24] Alternatively, displacement techniques, such as hydrodisplacement with fluid, instillation of gas, or manual manipulation of the ablation applicator, may create increased distance between kidney and bowel.[23,25]

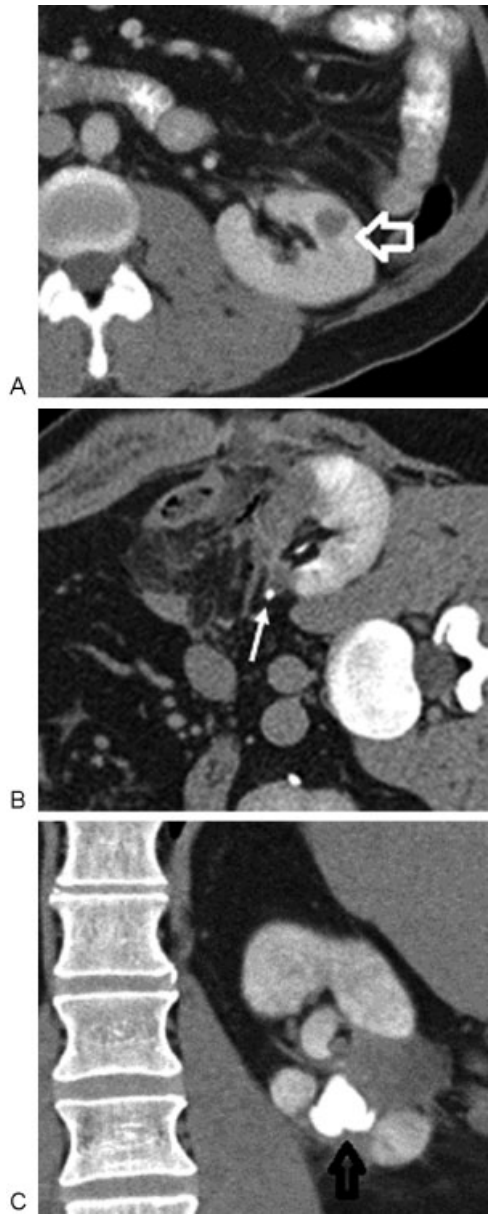

Figure 4 UPJ stricture following renal RFA. (A) Contrast-enhanced CT shows a 1.5-cm mass in the left mid kidney (arrow) of a 46-year-old man. Percutaneous RFA was proposed due to significant medical comorbidities and history of left partial nephrectomy for RCC. (B) Contrast-enhanced CT immediately following RFA shows the ablation zone encompassing the proximal ureter at the UPJ (arrow). (C) Coronal delayed contrast-enhanced CT 3 months later shows a dilated left intrarenal collecting system (arrow) due to UPJ stricture. This kidney eventually became atrophic and nonfunctional. CT, computed tomography; RCC, renal cell carcinoma; RFA, radiofrequency ablation; UPJ, Ureteropelvic junction.

Pneumothorax

Pleural transgression may occur when percutaneously treating an upper pole renal mass in proximity to the lung base, leading to pneumothorax in some cases (►**Fig. 7**). The

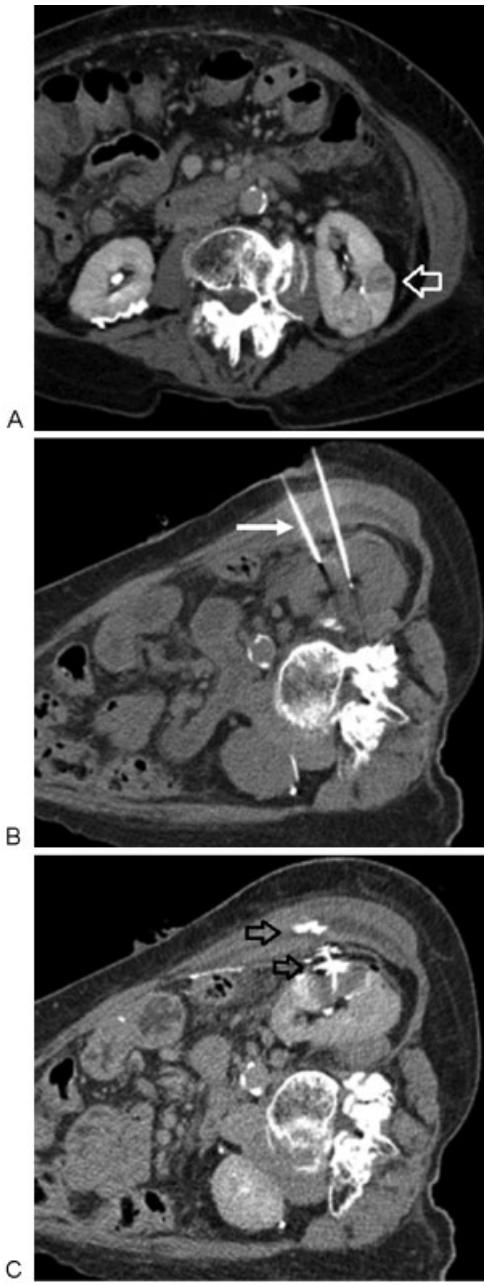

Figure 5 Urine leak after renal radiofrequency ablation. (A) Contrast-enhanced CT shows a 1.7-cm mass in the left mid kidney (arrow) in a 74-year-old woman status postright partial nephrectomy for RCC. (B) Unenhanced CT shows an RFA electrode in the tumor with tip at the renal sinus fat. A small catheter (arrow) is also in place for hydrodisplacement of the adjacent colon. (C) Delayed contrast-enhanced CT immediately following RFA shows urine leaking along the electrode tract (arrows). Due to its persistence on delayed imaging the following day, the urine leak was treated with a ureteral stent for 6 weeks. CT, computed tomography; RCC, renal cell carcinoma; RFA, radiofrequency ablation.

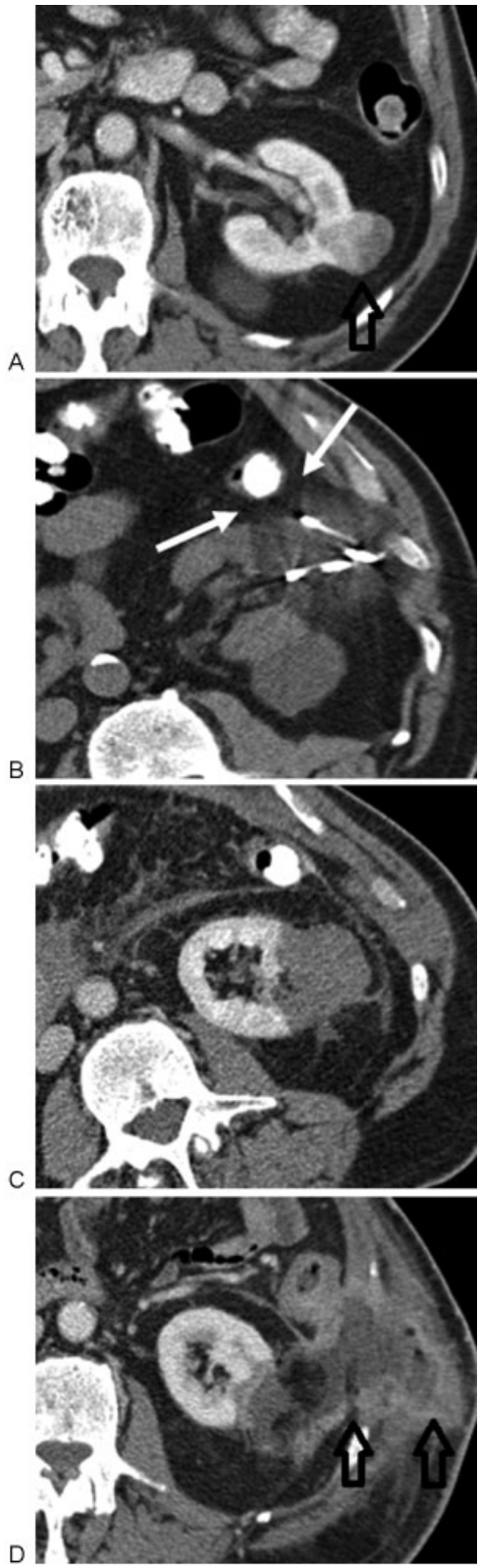

Figure 6 Abscess due to bowel perforation. (A) CT shows a 3.2-cm mass in the left mid kidney (arrow) in an 81-year-old man. (B) CT during cryoablation shows the ice ball (arrows) to encroach upon the descending colon. (C) CT immediately postablation shows complete ablation of the mass. (D) CT performed 2 months later shows a large abscess in the left retroperitoneum and chest wall (arrows), communicating with the ablation zone, presumably related to colonic perforation. CT, computed tomography.

reported incidence of pneumothorax is up to 2%.[1,11,23] Most are asymptomatic and self-limited; however, a moderate or large pneumothorax may require aspiration or chest tube placement. Intentional pneumothorax to allow transgression of the pleural space without crossing the lung has been described in the treatment of a renal mass.[23]

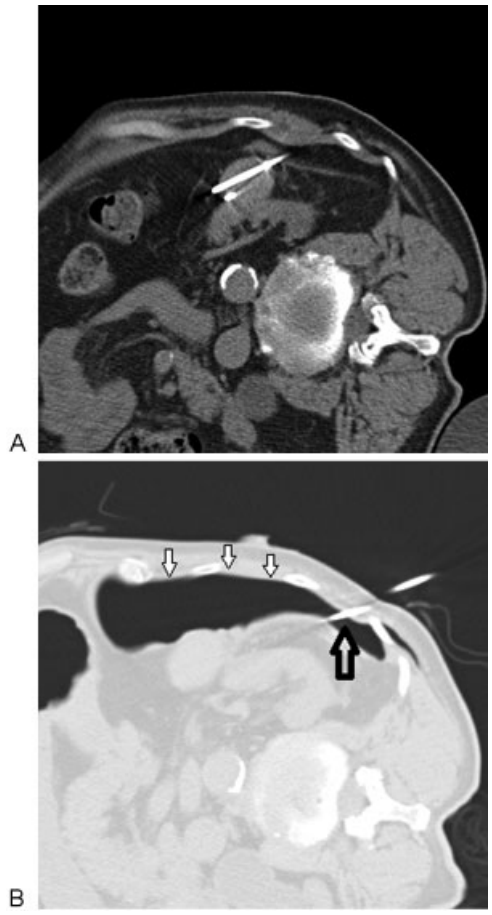

Figure 7 Pneumothorax during renal cryoablation. (A) CT image shows two cryoprobes within an exophytic left renal mass in an 82-year-old man. (B) CT image from a more superior level shows the cryoprobes crossing the pleural space (black arrow) with a moderate-sized pneumothorax (small white arrows). This was resolved with overnight catheter drainage. CT, computed tomography.

Skin Burn

Skin burns have been reported following percutaneous renal RFA with up to 1% incidence.[1,9] These occur at grounding pad sites due to improper dispersion of the RF energy. Alternatively, the ice ball created during renal cryoablation could theoretically encroach upon the skin and lead to thermal injury, particularly in thin patients with limited perinephric and subcutaneous fat. Careful intraprocedural monitoring should prevent these injuries.

Nerve Injury

Several nerves, most of which are not visible despite imaging guidance, are at risk of injury during percutaneous renal tumor ablation.[26] Specifically, extension of the ablation zone into the intercostal/subcostal nerves of the lower chest or nerves of the lumbar plexus in or about the psoas muscle may lead to sensory or motor changes. Sensory nerve injury may manifest as pain, anesthesia, or paresthesias in specific dermatomal or sensory nerve distributions. Motor nerve injury may present as abdominal wall laxity, which the patient may interpret as swelling or a hernia. Nerve injury is more often reported following RFA than cryoablation, occurring in 1 to 6% of procedures.[1,9,11,23,27,28] It is unclear whether tract ablation during renal RFA or direct electrical nerve stimulation by RF energy contributes to the risk of adjacent nerve injury.

The risk of nerve injury may be minimized by displacement techniques during ablation. Instillation of fluid or gas into the perinephric or paranephric fat may insulate these nerves and separate the index tumor from the body wall.[29] Similarly, manipulation of the ablation applicators may allow manual displacement of the tumor.[28]

Tract Seeding

Tumor seeding of the needle or probe tract made during percutaneous biopsy or ablation of RCC is very uncommon, reported in far fewer than 1% of cases (►**Fig. 8**).[1,8,30] A more common setting appears to be the presence of an inflammatory mass along the ablation tract, which can serve as a mimicker of local tumor recurrence.[9,23,31]

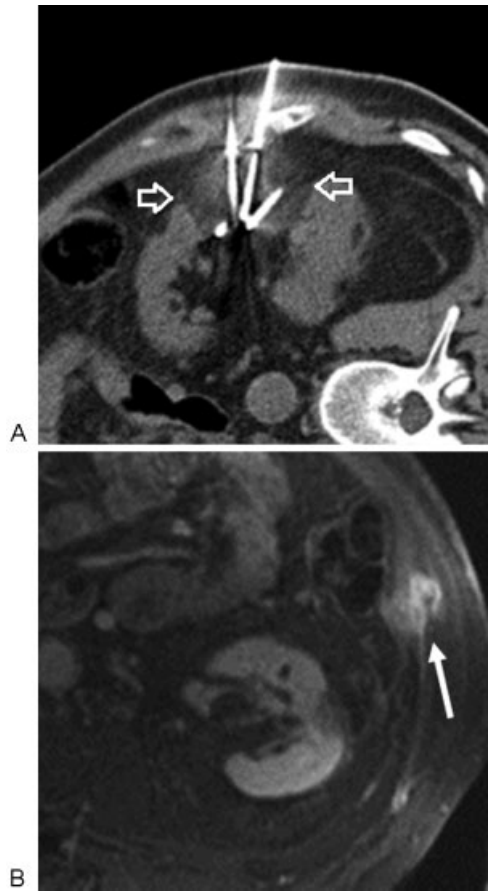

Figure 8 Tumor seeding following cryoablation. (A) CT image shows multiple cryoprobes entering through the left anterolateral abdominal wall and an ice ball (arrows) encasing a 3.5-cm left renal cell carcinoma in an 81-year-old man. (B) Postgadolinium MR image shows an enhancing 2-cm nodule (arrow) in the abdominal wall at the site of prior cryoprobe placement. Biopsy confirmed metastatic RCC, and the nodule was then successfully treated with cryoablation. CT, computed tomography; MR, magnetic resonance; RCC, renal cell carcinoma.

Miscellaneous Complications

Several other, less common complications have been reported following percutaneous renal ablation. These include ileus, hypertension, arrhythmia, myocardial infarction, cerebrovascular event, pneumonia, pulmonary embolism, pulmonary edema, and segmental renal infarction.[1,9,11,23]

Additional Techniques to Minimize Complication Risk

Several techniques have already been described to minimize the risk of a major complication related to renal tumor ablation. Two additional procedures, specifically arterial line placement and renal mass embolization, can also be performed to minimize ablation risks. Arterial line placement for hemodynamic monitoring may be warranted in cases at relatively increased bleeding risk (i.e., large, central masses or patients with coagulation abnormalities), with target tumors at increased risk of hemodynamic changes during ablation due to proximity to the adrenal gland (i.e., medial upper pole lesions), and in patients with limited cardiovascular reserve (i.e., pre-existing anemia, coronary artery disease history). Furthermore, selective tumor embolization for larger renal tumors (i.e., those greater than 5 cm in maximal diameter) has been shown to decrease the degree of procedure-related retroperitoneal hemorrhage as measured on CT.[32]

Multidisciplinary Team

Multidisciplinary patient care, particularly involving urologists and anesthesiologists, may help optimize patient outcomes during and after the ablation. Anesthesia management and monitoring of hemodynamic and respiratory status is especially warranted for medically complicated patients. In the event of a periprocedural complication, such anesthesia involvement may be critical for early diagnosis and management. Similarly, taking advantage of the clinical and surgical expertise of urology colleagues following an ablation-related complication should best serve the patient over the short and long term.

Conclusion

Complications following percutaneous ablation of small renal masses are uncommon. However, knowledge of the potential complications, associated risk factors, and techniques used to minimize risk and treat these complications may allow interventional radiologists and urologists to optimize periprocedural care.

References

1 Atwell TD, Carter RE, Schmit GD, et al. Complications following 573 percutaneous renal radiofrequency and cryoablation procedures. J Vasc Interv Radiol 2012;23(1):48–54

2 Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240(2):205–213

3 Morgan M, Smith N, Thomas K, Murphy DG. Is Clavien the new standard for reporting urological complications? BJU Int 2009; 104(4):434–436

4 Common Terminology Criteria for Adverse Events (CTCAE) Version 4.0. In: U.S. Department of Health and Human Services

5 Sacks D, McClenny TE, Cardella JF, Lewis CA. Society of Interventional Radiology clinical practice guidelines. J Vasc Interv Radiol 2003;14(9 Pt 2):S199–S202

6 Campbell SC, Novick AC, Belldegrun A, et al; Practice Guidelines Committee of the American Urological Association. Guideline for management of the clinical T1 renal mass. J Urol 2009;182(4): 1271–1279

7 Johnson DB, Solomon SB, Su LM, et al. Defining the complications of cryoablation and radio frequency ablation of small renal tumors: a multi-institutional review. J Urol 2004;172(3):874–877

8 Hui GC, Tuncali K, Tatli S, Morrison PR, Silverman SG. Comparison of percutaneous and surgical approaches to renal tumor ablation: metaanalysis of effectiveness and complication rates. J Vasc Interv Radiol 2008;19(9):1311–1320

9 Gervais DA, McGovern FJ, Arellano RS, McDougal WS, Mueller PR. Radiofrequency ablation of renal cell carcinoma: part 1, Indications, results, and role in patient management over a 6-year period and ablation of 100 tumors. AJR Am J Roentgenol 2005;185(1):64–71

10 Hegarty NJ, Gill IS, Desai MM, Remer EM, O'Malley CM, Kaouk JH. Probe-ablative nephron-sparing surgery: cryoablation versus radiofrequency ablation. Urology 2006;68(1, Suppl):7–13

11 Zagoria RJ, Traver MA, Werle DM, Perini M, Hayasaka S, Clark PE. Oncologic efficacy of CT-guided percutaneous radiofrequency ablation of renal cell carcinomas. AJR Am J Roentgenol 2007; 189(2):429–436

12 Atwell TD, Farrell MA, Leibovich BC, et al. Percutaneous renal cryoablation: experience treating 115 tumors. J Urol 2008;179(6): 2136–2140, discussion 2140–2141

13 Gupta A, Allaf ME, Kavoussi LR, et al. Computerized tomography guided percutaneous renal cryoablation with the patient under conscious sedation: initial clinical experience. J Urol 2006;175(2): 447–452, discussion 452–453

14 Silverman SG, Tuncali K, vanSonnenberg E, et al. Renal tumors: MR imaging-guided percutaneous cryotherapy—initial experience in 23 patients. Radiology 2005;236(2):716–724

15 Atwell TD, Schmit GD, Boorjian SA, et al. Percutaneous ablation of renal masses measuring 3.0 cm and smaller: comparative local control and complications after radiofrequency ablation and cryoablation. AJR Am J Roentgenol 2013;200(2):461–466

16 Schmit GD, Thompson RH, Boorjian SA, et al. Percutaneous renal cryoablation in obese and morbidly obese patients. Urology 2013; 82(3):636–641

17 Sutor AH, Bowie EJ, Owen CA Jr. Effect of temperature on hemostasis: a cold-tolerance test. Blut 1971;22(1):27–34

18 Schmit GD, Atwell TD, Callstrom MR, et al. Ice ball fractures during percutaneous renal cryoablation: risk factors and potential implications. J Vasc Interv Radiol 2010;21(8):1309–1312

19 Brashears JH III, Raj GV, Crisci A, et al. Renal cryoablation and radio frequency ablation: an evaluation of worst case scenarios in a porcine model. J Urol 2005;173(6):2160–2165

20 Janzen NK, Perry KT, Han KR, et al. The effects of intentional cryoablation and radio frequency ablation of renal tissue involving the collecting system in a porcine model. J Urol 2005;173(4): 1368–1374

21 Cantwell CP, Wah TM, Gervais DA, et al. Protecting the ureter during radiofrequency ablation of renal cell cancer: a pilot study of retrograde pyeloperfusion with cooled dextrose 5% in water. J Vasc Interv Radiol 2008;19(7):1034–1040

22 Froemming A, Atwell T, Farrell M, Callstrom M, Leibovich B, Charboneau W. Probe retraction during renal tumor cryoablation: a technique to minimize direct ureteral injury. J Vasc Interv Radiol 2010;21(1):148–151

23 Park BK, Kim CK. Complications of image-guided radiofrequency ablation of renal cell carcinoma: causes, imaging features and prevention methods. Eur Radiol 2009;19(9):2180–2190
24 Gervais DA, Arellano RS, McGovern FJ, McDougal WS, Mueller PR. Radiofrequency ablation of renal cell carcinoma: part 2, Lessons learned with ablation of 100 tumors. AJR Am J Roentgenol 2005; 185(1):72–80
25 Farrell MA, Charboneau JW, Callstrom MR, Reading CC, Engen DE, Blute ML. Paranephric water instillation: a technique to prevent bowel injury during percutaneous renal radiofrequency ablation. AJR Am J Roentgenol 2003;181(5):1315–1317
26 Kurup AN, Morris JM, Schmit GD, et al. Neuroanatomic considerations in percutaneous tumor ablation. Radiographics 2013;33(4): 1195–1215
27 Bhayani SB, Allaf ME, Su LM, Solomon SB. Neuromuscular complications after percutaneous radiofrequency ablation of renal tumors. Urology 2005;65(3):592
28 Boss A, Clasen S, Kuczyk M, et al. Thermal damage of the genitofemoral nerve due to radiofrequency ablation of renal cell carcinoma: a potentially avoidable complication. AJR Am J Roentgenol 2005;185(6):1627–1631
29 Lee SJ, Choyke LT, Locklin JK, Wood BJ. Use of hydrodissection to prevent nerve and muscular damage during radiofrequency ablation of kidney tumors. J Vasc Interv Radiol 2006;17(12):1967–1969
30 Silverman SG, Gan YU, Mortele KJ, Tuncali K, Cibas ES. Renal masses in the adult patient: the role of percutaneous biopsy. Radiology 2006;240(1):6–22
31 Lokken RP, Gervais DA, Arellano RS, et al. Inflammatory nodules mimic applicator track seeding after percutaneous ablation of renal tumors. AJR Am J Roentgenol 2007;189(4):845–848
32 Woodrum DA, Atwell TD, Farrell MA, Andrews JC, Charboneau JW, Callstrom MR. Role of intraarterial embolization before cryoablation of large renal tumors: a pilot study. J Vasc Interv Radiol 2010; 21(6):930–936